

Technology Validation: Fuel Cell Bus Evaluations

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TV10**

This presentation does not contain any proprietary, confidential, or otherwise restricted information

Overview

Timeline

- Evaluations typically cover two years of data
- Start date determined by bus delivery
- International collaboration ongoing

Budget

- FY 2007: \$288K
- FY 2006: \$288K
- FY 2005: \$338 K

Barriers

- A. Lack of fuel cell vehicle performance and durability data
- C. Lack of H₂ fueling infrastructure performance and availability data
- D. Maintenance and training facilities

Partners

- Fleets: Operational data, fleet experience
- Manufacturers: Vehicle specs, data and review
- Fuel Providers: Fueling data and review
- International: Exchange of results

Objectives

- Overall: Validate fuel cell and hydrogen technologies in transit applications
 - Show progress of the technology toward commercialization
 - Provide “lessons learned” on implementing next generation fuel cell systems in transit operations
 - Harmonize data collection efforts with other fuel cell bus demonstrations worldwide (in coordination with FTA and other U.S. and international partners)
- 2006
 - Complete analysis and reporting on VTA
 - Complete interim analysis and reporting for AC Transit and SunLine

Evaluation of Hydrogen and Fuel Cell Buses in Four Fleets

Santa Clara VTA, San Jose, CA

Ballard FC System: non-hybrid



AC Transit, Oakland, CA

UTC Power, ISE Corp: hybrid FCB



SunLine, Thousand Palms, CA

UTC Power, ISE Corp: hybrid FCB

ISE Corp: hybrid H₂ ICE



Hickam AFB, Honolulu, HI

Hydrogenics, Enova: hybrid system



Comparison of Hydrogen and Fuel Cell Buses to Conventional Technology

Targets for assessing the progress toward commercialization

- Performance characteristics
- Bus use
- Fuel economy
- Availability
- Reliability - miles between road call (MBRC)
- Cost - capital, fueling, and maintenance

Fleet Data Summary: Santa Clara VTA

Fuel Cell Bus (non-hybrid system)

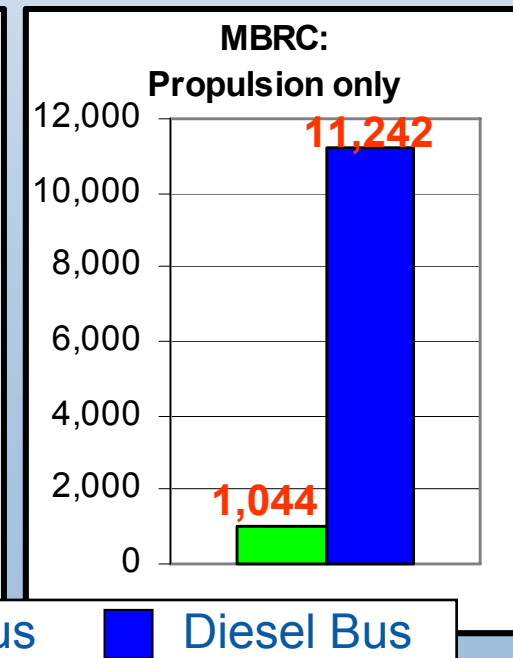
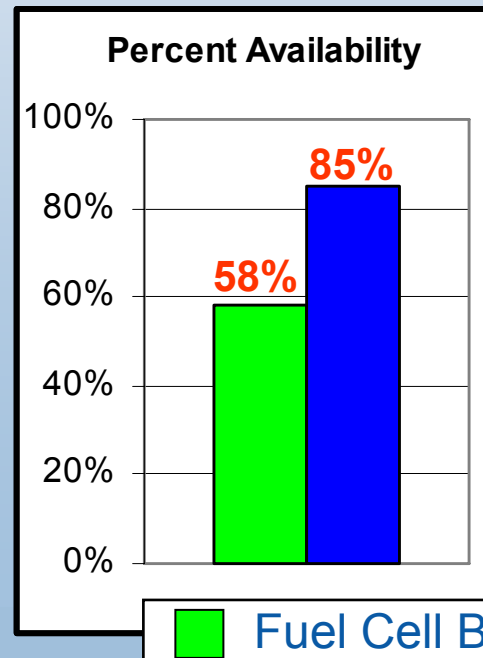
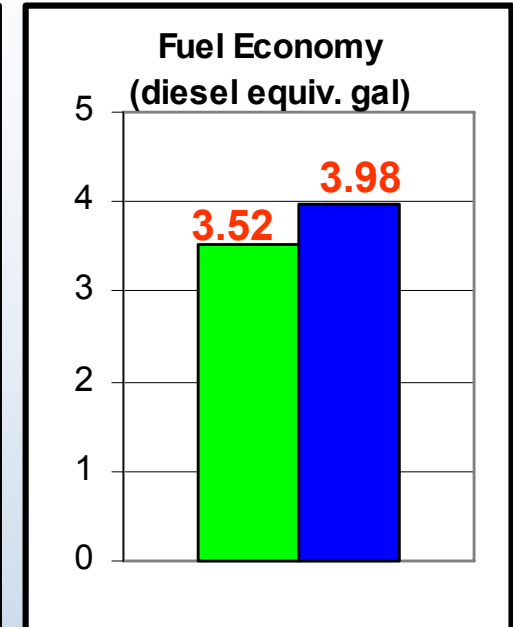
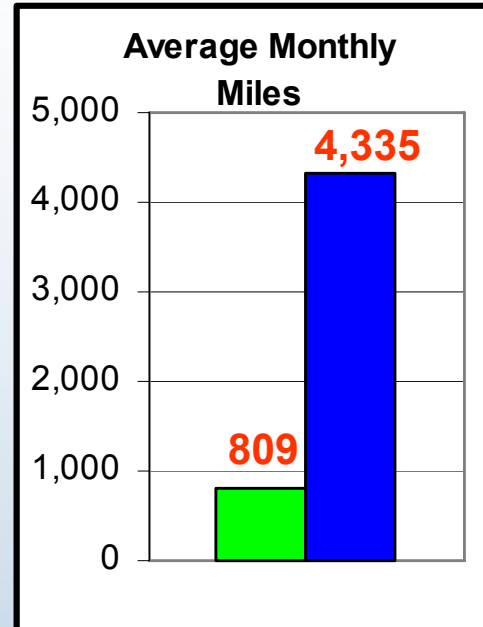


- 17 months operation of 3 FCBs
- Total miles: 40,208
- Total FC system hours: 3,219

Diesel Bus (baseline)



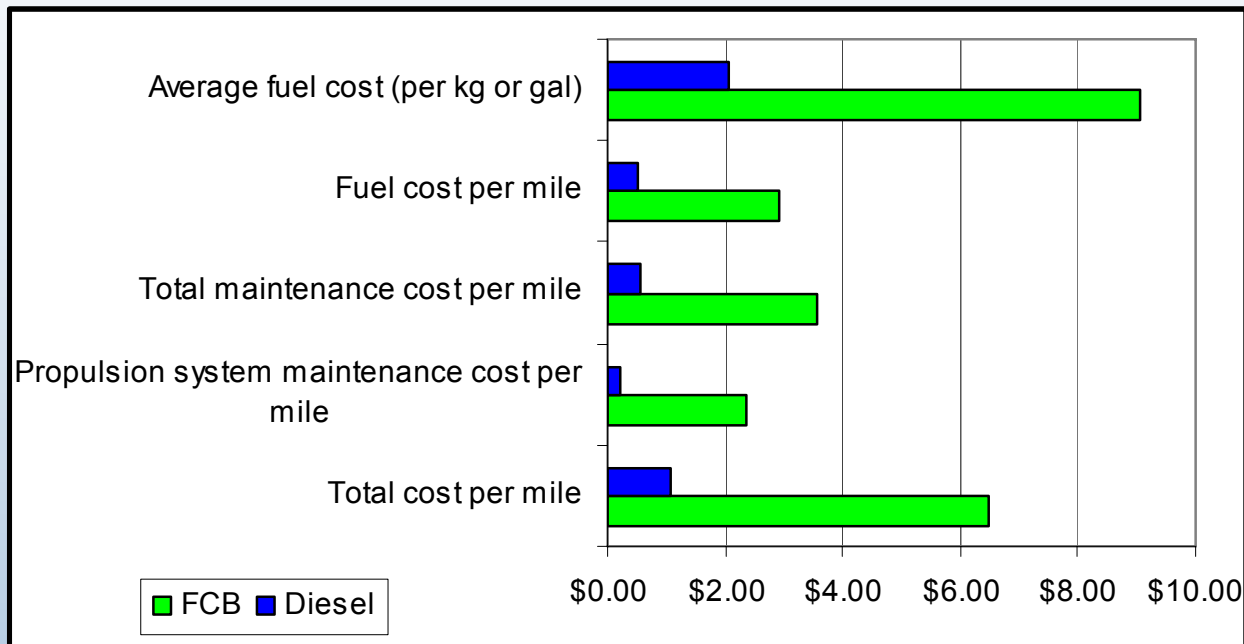
- 17 months operation of 5 diesel buses
- Total miles: 360,447



Fuel Cell Bus Diesel Bus

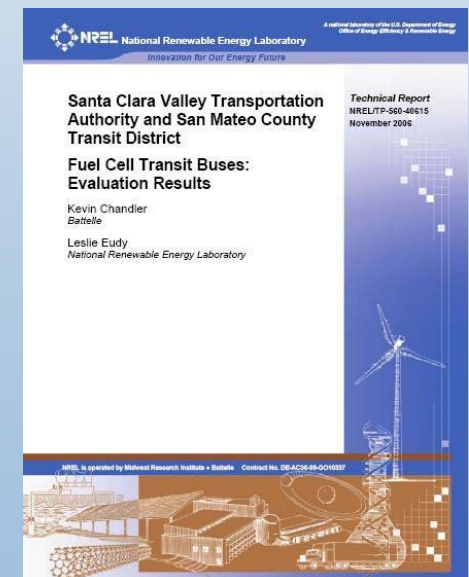
Fleet Data Summary: Santa Clara VTA

Summary of Costs



Evaluation Status

- Complete
- Report published



Report available online at
www.nrel.gov/hydrogen/pdfs/40615.pdf

Fleet Data Summary: AC Transit

Fuel Cell Bus (hybrid system)

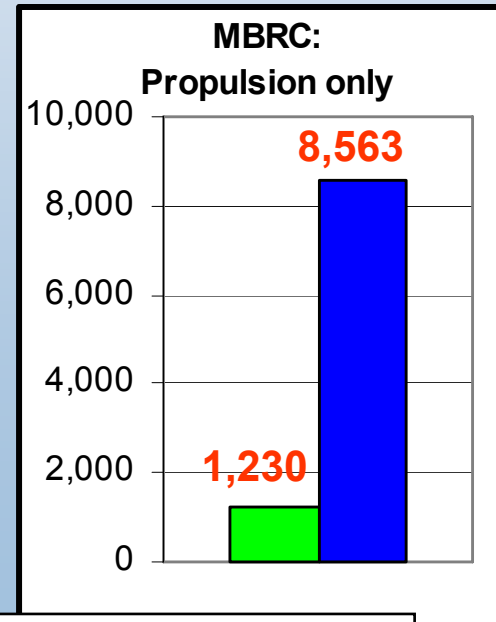
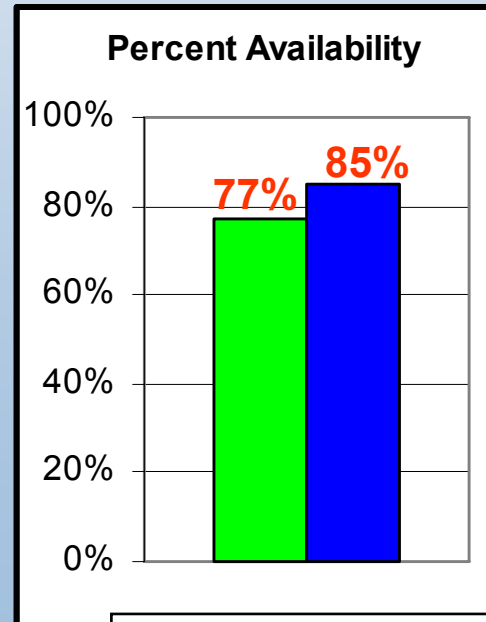
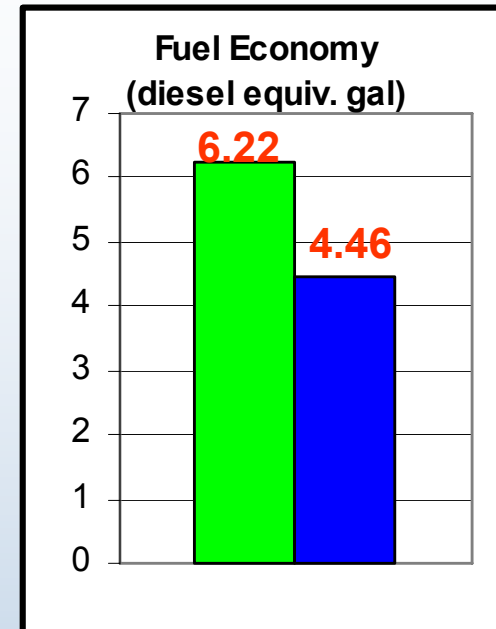
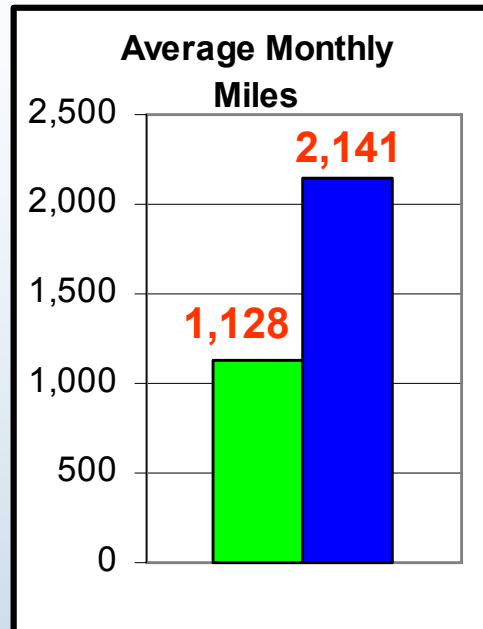


- 8 months operation of 3 FCBs
- Total miles: 27,065
- Total FC system hours: 2,338

Diesel Bus (baseline)



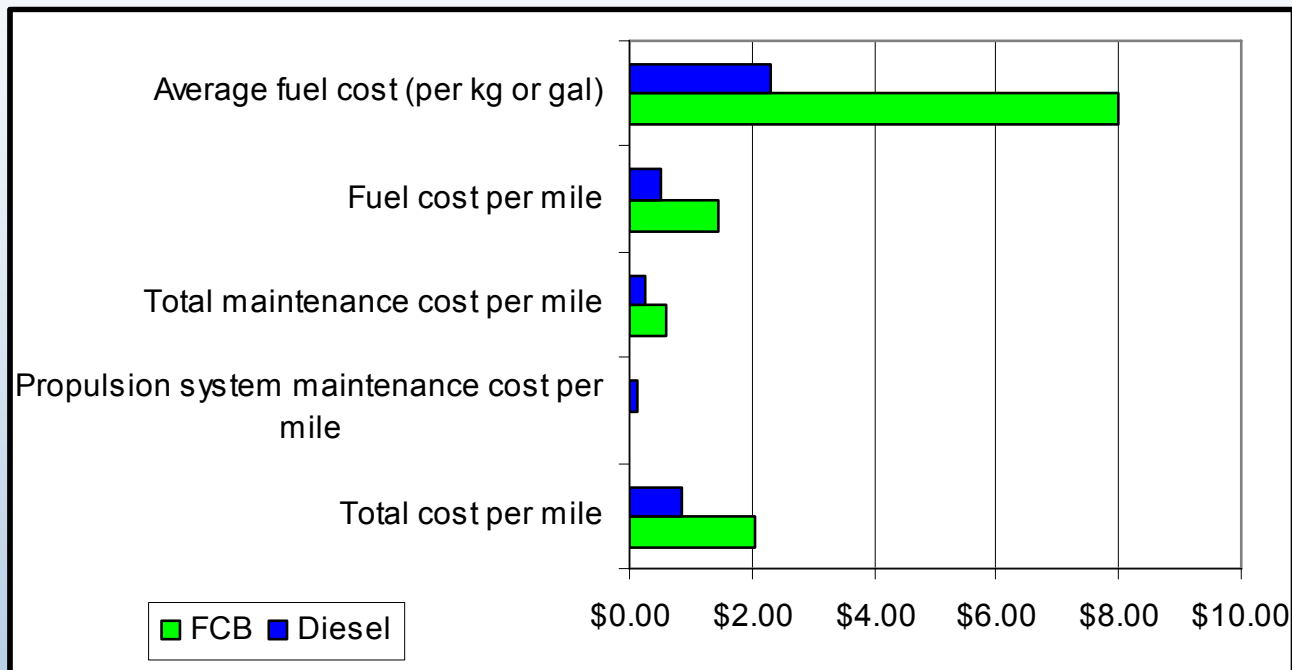
- 8 months operation of 6 diesel buses
- Total miles: 102,755



■ Fuel Cell Bus ■ Diesel Bus

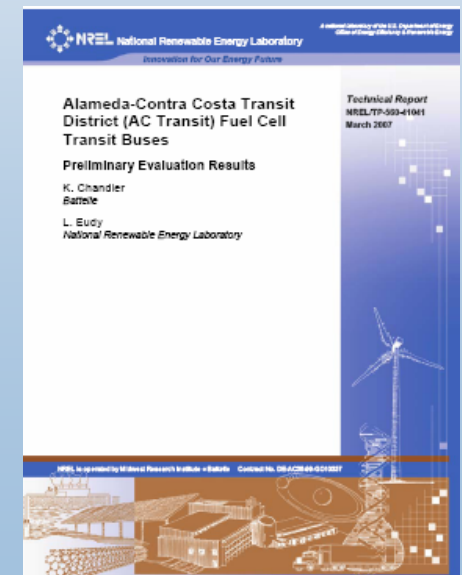
Fleet Data Summary: AC Transit

Summary of Costs



Evaluation Status

- Data collection ongoing
- Interim report published
- Second data report planned for fall 2007

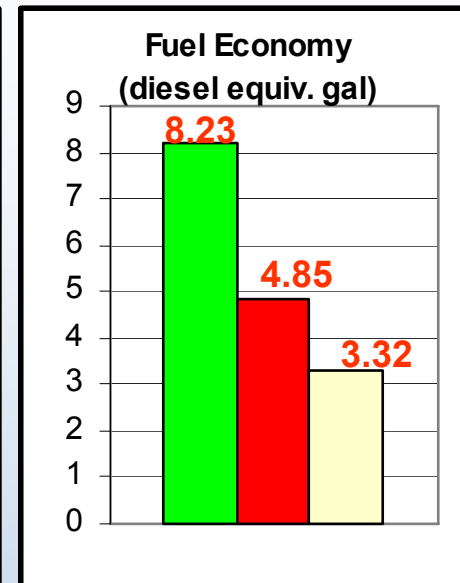
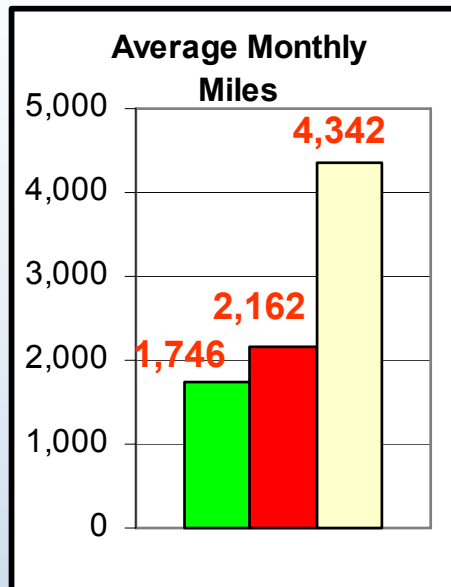
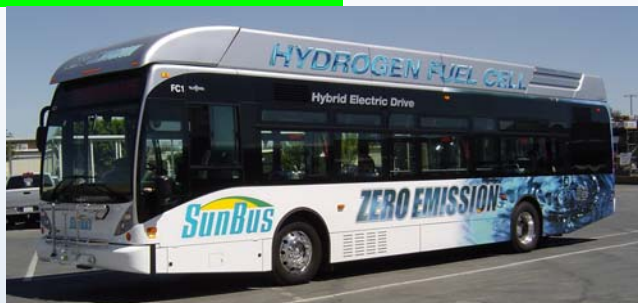


Report available online at
www.nrel.gov/hydrogen/pdfs/41041.pdf

Fleet Data Summary: SunLine

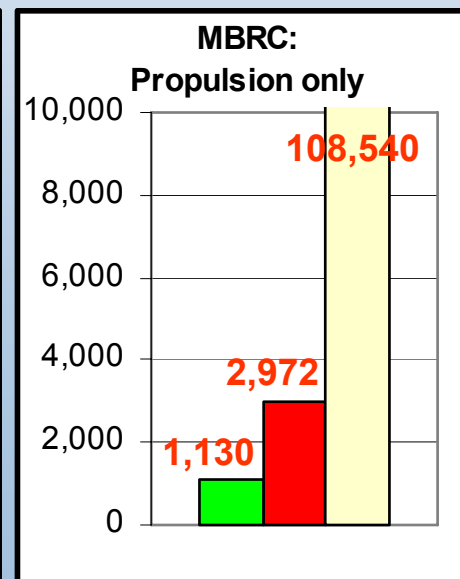
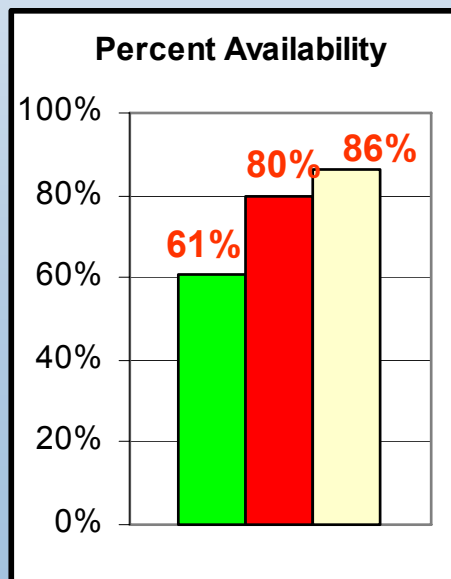
Fuel Cell Bus (hybrid system)

- 11 months operation of 1 FCB
- Total miles: 19,208
- Total FC system hours: 1,345



HHICE Bus

- 11 months operation of 1 HHICE bus
- Total miles: 23,661



CNG Bus

- 5 months operation of 5 CNG buses
- Total miles: 108,540

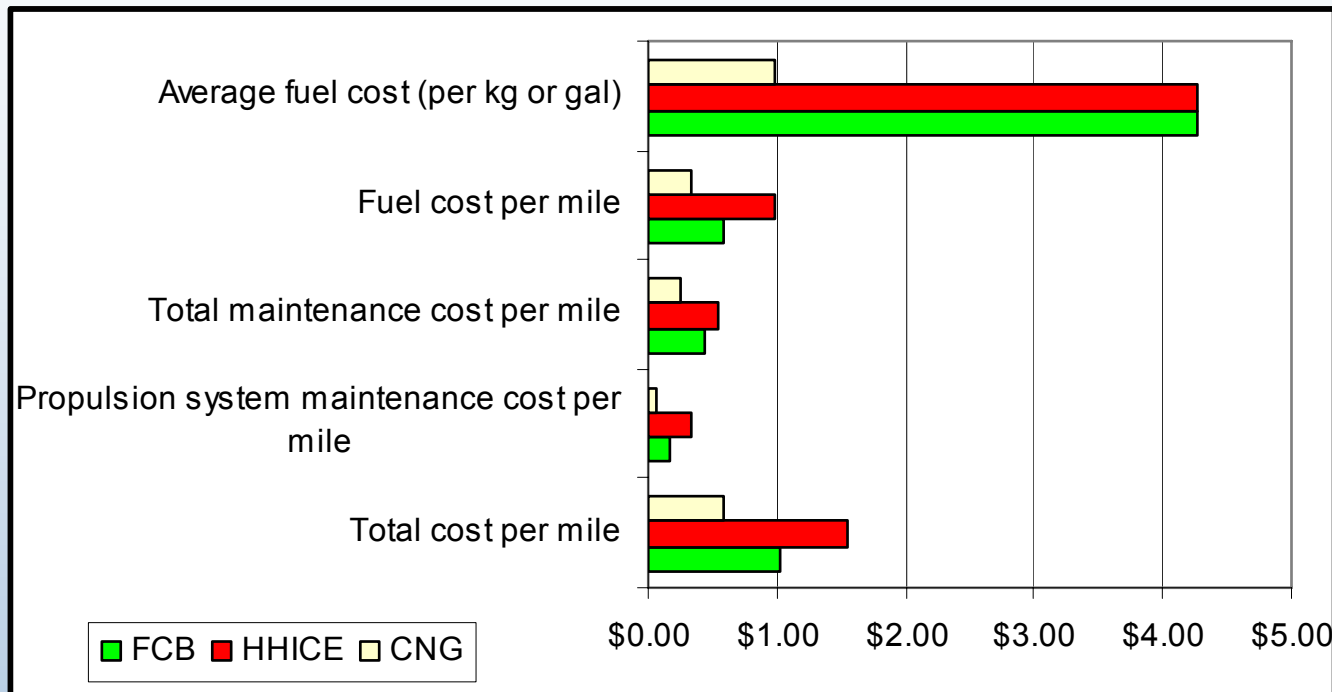


■ Fuel Cell Bus
 ■ HHICE bus
 ■ CNG Bus

*HHICE – hybrid H₂ internal combustion engine

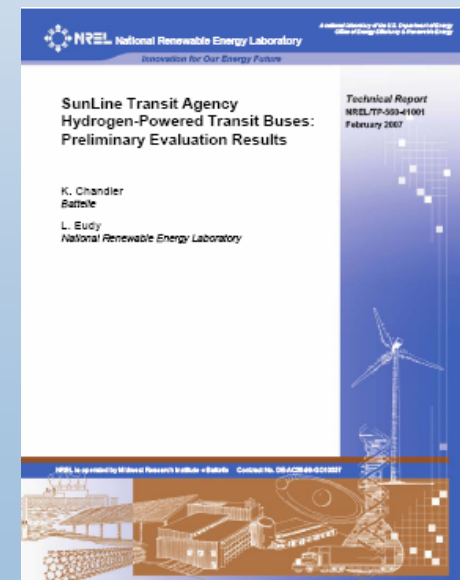
Fleet Data Summary: SunLine

Summary of Costs



Evaluation Status

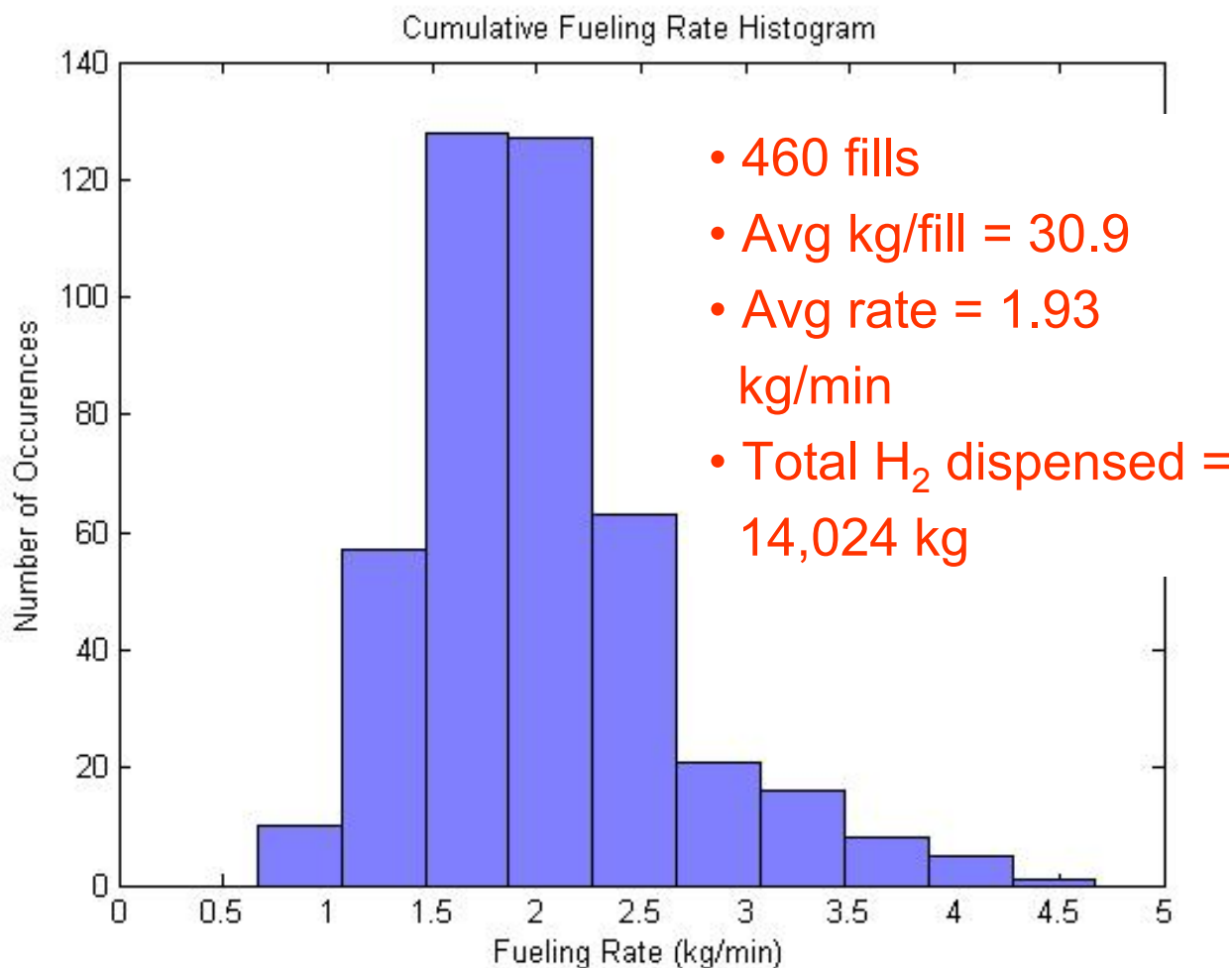
- Data collection ongoing
- Interim report published
- Second data report planned for fall 2007



Report available online at
www.nrel.gov/hydrogen/pdfs/41001.pdf

Infrastructure Data Summary: VTA

VTA H₂ Fueling Station



VTA fueling station:

- Air Products
- Liquid H₂ storage
- Dispenses compressed H₂

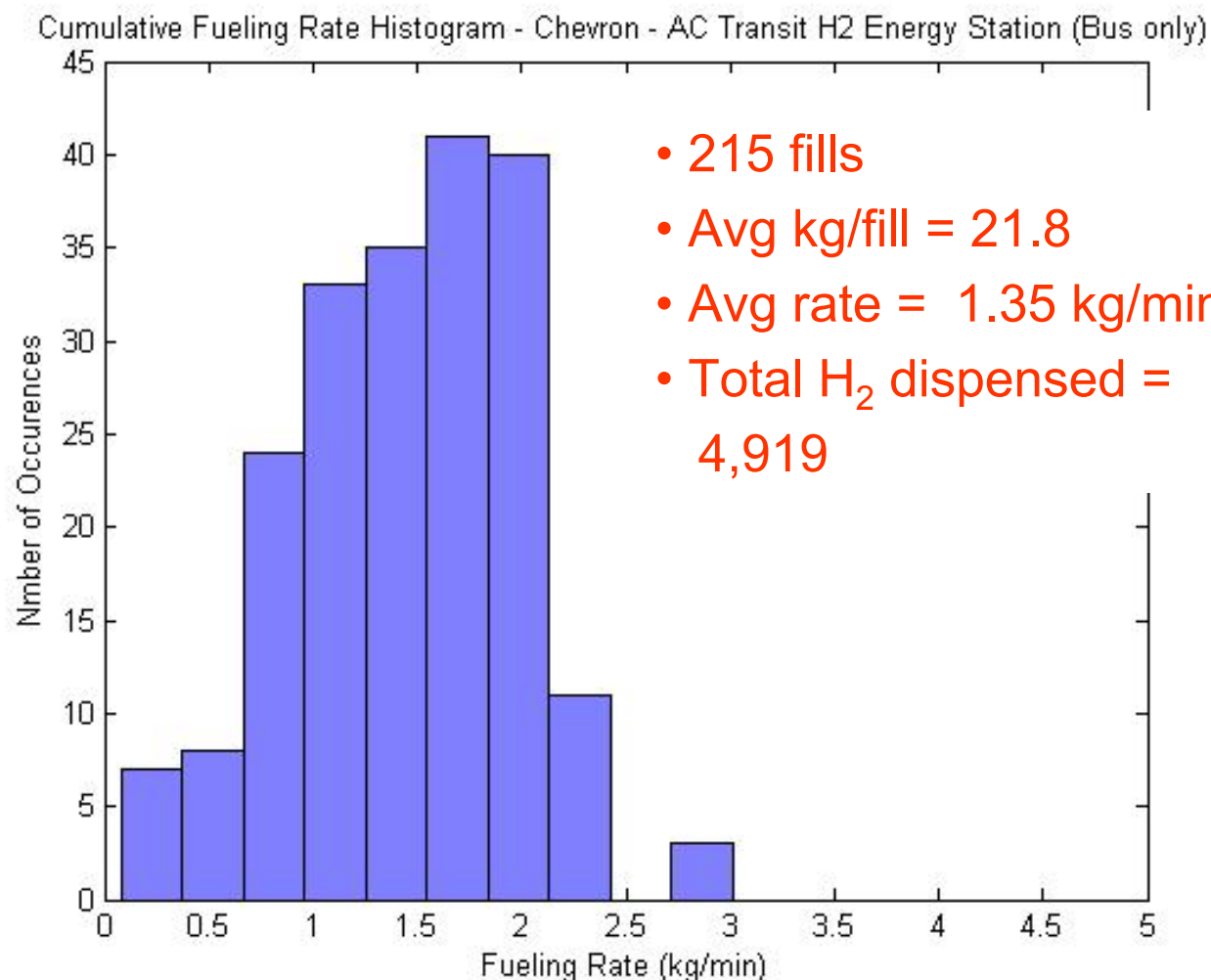
Infrastructure Data Summary: AC Transit

Chevron - AC Transit H₂ Energy Station



ACT fueling station:

- Chevron Technology Ventures
- Natural gas reformer
- 150 kg H₂ per day
- 366 kg storage



Hickam Air Force Base: Status

Demonstration of two fuel cell vehicles

Vehicles

- 1 ElDorado 30-ft bus
 - Enova battery-dominant hybrid FC system, Hydrogenics 20kW FC
- 1 step van
 - Enova hybrid FC system, Hydrogenics 60kW FC



Status

- H₂ fueling available in late 2006
- Bus operating as visitor shuttle on base and in surrounding area
- Step van in service as maintenance support vehicle
- Interim report scheduled for publication in fall 2007

International Collaboration

4th workshop held in Yokohama, Japan in October 2006

- Overall goal: enhance information sharing and data exchange between international FCB demos
- Group discussion:
 - Developed a list of performance data available to share from all projects
 - Listed concerns and issues that must be solved prior to sharing
 - Established action items and a timeline for accomplishment
- Planning 5th International Fuel Cell Bus Workshop in summer 2008

IPHE
Recognized
Event



Future Work

- Remainder of FY 2007
 - Data analysis and draft preliminary data report on Hickam evaluation
 - Complete second data analysis and reports on AC Transit and SunLine
 - Collect more technical data on FCBs and infrastructure to complement DOE Controlled Fleet Demo
- FY 2008
 - Complete analysis and final data report on Hickam
 - Complete final data analysis and reports on SunLine and AC Transit
 - Initiate data collection for additional fleets

Summary

- Collected operational, performance, and cost data on 8 hydrogen fueled buses in real-world service at three transit agencies:
 - VTA: 17 months
 - SunLine: 11 months
 - AC Transit: 8 months
- Validated fuel cell bus performance characteristics equal to or better than diesel
 - Drivers report better acceleration and quiet operation
- Demonstrated that bus duty-cycle allows fast accumulation of miles/FC hours
 - Accumulated over 110,000 total miles and over 6,900 FC hours
- Collected performance and cost data on conventional technology to establish a baseline for tracking progress
 - Use of prototype FCBs is much less than standard buses
 - High cost for maintaining current generation prototype technology

Summary (continued)

- Fuel cell bus use less than baseline
 - Range from 50% below to 81% below standard bus use
- Fuel economy
 - Fuel economy results show need for hybridization
 - Improvement over conventional technology approaching 2X
 - Highly dependent on duty-cycle

